AUGMENTED REALITY IN SECONDARY EDUCATION. DESCRIPTIVE STUDY OF TEACHERS' OPINIONS

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Abstract

The technological revolution in the educational field is today an undeniable reality, which is why its presence in classrooms is increasingly prevalent. However, it is not without controversy, one of which is the perspective of the teaching staff, as this will determine its use or non-use. We present the preliminary findings of a larger study that outlines the views of a group of trainee teachers in the secondary education stage in Spain regarding the presence of augmented reality in classrooms. The main finding has indicated that the variables of age and macro-area of study do not show differences in the beliefs they hold about its use in the classroom. Gender appears to be a distorting factor in some respects. We can conclude that training is needed both for its incorporation into classroom methodology and for its promotion within inclusive environments.

Keywords: *mixed reality, teacher, secondary education, learn, teach*

1. INTRODUCTION

The contemporary world of the 21st century is the result of the evolution of the information and knowledge society, as well as the powerful transformations occurring across all areas of development. This has led to an unprecedented revolution in the tools used within educational processes, which are currently supported by information and communication technologies (ICT). These technologies have become a key factor in the change and progress of communities (Colas et al., 2018).

In this regard, the incorporation of digital tools in classrooms implies, on one hand, taking into account the beliefs, perspectives, and training that teachers have towards these tools, and on the other hand, considering the students' stance when linking learning to their use. Similarly, educational administrations will play a crucial role, as they will initially facilitate not only the academic integration of these tools but also their presence in educational institutions from an economic standpoint.

In light of this scenario, emerging technologies such as augmented and virtual reality become dynamic elements in the teaching and learning processes. When focusing on augmented reality, it is important to consider that its presence in the classroom must become a reality.

The Augmented Reality (AR), providing immersive and dynamic educational experiences. Within the context of secondary education, teachers' beliefs about AR are crucial for its adoption and success in the classroom.

The integration of Augmented Reality (AR) into the secondary education curriculum is a subject of increasing interest among educators. In this regard, we concur with Marín et al. (2023) that this technology can provide unique opportunities to enhance teaching and learning, as well as present significant challenges to the methodologies employed in the classroom.

The amalgamation of real-world and virtual elements to forge a new environment where physical and digital objects coexist and can interact in real-time. This technology harbours the potential to facilitate richer and more diverse learning experiences, tailored to the individual needs of each student.

Focusing on the role of the teacher, numerous studies have been conducted over the years regarding their digital positioning concerning classroom methodologies (Acosta et al., 2019).

Educators acknowledge that AR can foster more active, collaborative, and engaging teaching, enabling students to interact with digital content within a real-world context. However, they also express the need for specific training to implement these technologies effectively.

Several studies conducted (Rodríguez, 2021; Marín et al., 2023, 2022) indicate that teachers at this educational stage perceive Augmented Reality (AR) as a tool of great power and versatility. This perception suggests that AR will not only enrich the curriculum but will also provide deeper and more meaningful learning experiences. Specifically, the faculty states that it will: facilitate the understanding of abstract concepts through interactive visualizations; promote exploratory and discovery-based learning; and increase student motivation and engagement with the course content.

In this vein, we find the work conducted by Encarnación and Ayala (2021), where their research evaluated the influence of Augmented Reality (AR) on the theoretical-practical learning of upper secondary education students. The study employed a mixed-methods approach and relied on pretests and post-tests to assess specific learning outcomes in hardware architecture. Furthermore, the applications Creator AVR and PC Building were utilized to facilitate learning. The Technology Acceptance Model (TAM) was used to evaluate aspects such as ease, usability, and utility of AR. The results showed that 79.2% of the theoretical-practical knowledge improved, and high ratings were observed in utility and usability, indicating that AR can be an effective tool to support student learning. This study provides valuable insight into how AR can be integrated into the classroom to enhance theoretical-practical learning, and how teachers can use this technology to enrich the educational experience of their students.

Overall, then, it will help to improve knowledge retention and foster critical thinking skills (García-Crespo & López-Belmonte, 2022)

Nevertheless, as with any new approach to developing teaching and learning methodologies, it is not free from presenting some difficulties, which can generate concern about how the formative process will be affected. In this regard, some of these concerns or barriers in its application in the classroom revolve around aspects such as: The need for adequate training for teachers in the use of AR, the lack of resources and technical support in educational institutions, and the possibility that AR may distract more than assist in the learning process. In addition, de la Horra (2017), Villalustre (2020) and Marín et al (2022) point out that the lack of experience and confidence in handling emerging technologies can be a significant barrier for some teachers.

In conclusion, the main advantages of AR in Secondary Education will be:

Immersive Learning: Augmented Reality allows students to immerse themselves in virtual environments that enrich the understanding of content.

Interactivity: It encourages active participation of students by interacting with virtual objects.

Motivation: Immersive experiences can increase students' interest and motivation towards learning.

And the disadvantages of AR in Secondary Education:

Cost: The implementation of AR may require a significant investment in hardware and software.

Learning Curve: Both teachers and students may need time to adapt to new technologies.

Accessibility: There may be limitations regarding accessibility for all students, especially in environments with limited resources.

In any case, its use entails a series of implications or practical applications that will help overcome the initial barriers. These would include the scheduling of continuous training and support for teachers in the use and creation of AR, the provision of resources and accessible tools for effective implementation, and the design of curricular integration strategies that align AR with learning objectives. In this regard, Martín-Gutiérrez and Contero (2023) suggest that collaboration among educators, technology developers, and pedagogy experts is crucial for designing AR experiences that are pedagogically robust and relevant to the curriculum.

2. MATERIALS AND METHODS

2.1. Methods

This research is framed on one hand within a descriptive approach using cross-sectional survey methodology, with a quantitative orientation, in accordance with the numerical and reliable nature of the collected data. On the other hand, it follows a deductive and structured research strategy. Through a quantitative, descriptive, and correlational study, employing an ex-post facto design (León & Montero, 2011), this research has been developed. To this end, an ad hoc questionnaire was designed, which bases its items on the legislation currently governing the Secondary Education stage. The main objective of this work was to understand the perspective of future Secondary Education teachers regarding the use of Augmented Reality in teaching at this educational level. In light of this, the following specific objectives and initial hypotheses have been established.

Specific Objectives:

1. To describe the perspective of pre-service secondary education teachers regarding the potential use of Augmented Reality (AR) in secondary school classrooms.
2. To clarify differences in perceptions related to the use of AR in Secondary Education, both in terms of classroom work mediated by AR and the combination of AR and Special Educational Needs and Disabilities (NEAE).
3. To analyse the perspective of pre-service secondary education teachers on classroom work mediated by AR, considering the comprehensive influence of independent variables such as gender, age, and the macro-area of their master's degree program.

Hypotheses:

1. H1: Women are more favourable towards using AR for curricular development in secondary education.
2. H2: Younger pre-service teachers have a more positive view of incorporating AR as a methodological element in secondary school classrooms.
3. H3: Significant differences exist based on the macro-area of study origin.

2.2. Instrument

To carry out this research, a questionnaire was designed. The questionnaire aimed to address the objectives of the project, which regulates the administration of secondary education in Spain.

Initially, the questionnaire consisted of 39 items. The first three items corresponded to sociodemographic and academic independent variables related to gender, age, and the macro areas based on the university degree completed prior to the master's program. The remaining 36 items were closed-ended questions with a Likert scale response format, ranging from "totally disagree" (1) to "totally agree" (5).

The validity of the instrument was assessed through an Exploratory Factor Analysis (EFA) using the Factor Analysis software. Polychoric matrices were employed, along with a minimum rank factor analysis (MRFA) procedure and the Hull method for factor extraction. The analysis yielded a Kaiser-Meyer-Olkin (KMO) index of .842 [Chi2(351) = 4892.651; p = .000)}, and the total explained variance was 75.2%. The final result revealed the following bifactorial structure:

1. Classroom Work and Augmented Reality (AR): This factor comprised 21 items related to classroom work mediated by AR.
2. Augmented Reality (AR) and Specific Educational Support Needs (NEAE): This factor consisted of 6 items referring to aspects related to the use of AR in students with NEAE.

Items	1	2
1. The use of Augmented Reality (AR) will make the teaching methodology used in the classroom more participatory	.666	
2. The use of Augmented Reality (AR) can enhance multicultural education	.661	
3. The use of Augmented Reality (AR) will favour the critical spirit of students	.646	
4. The use of Augmented Reality (AR) allows collaborative work	.620	
5. The use of Augmented Reality (AR) allows cooperative work	.596	
6. The use of Augmented Reality (AR) can be used by subjects with high abilities	.584	
7. The use of Augmented Reality (AR) allows group work	.583	
8. The use of Augmented Reality (AR) will make the teaching methodology used in the classroom more active	.581	
9. The use of Augmented Reality (AR) will make the teaching methodology used in the classroom achieve, more effectively, the objectives of the subject in which it is used	.576	
10. The use of Augmented Reality (AR) can enhance intercultural education	.575	
11. The use of Augmented Reality (AR) will help in carrying out complex tasks associated with real situations or as contextualized as possible, linked to the subject in which it is used.	.574	
12. The use of Augmented Reality (AR) will favour students' ability to communicate what they have learned.	.568	
13. The use of Augmented Reality (AR) encourages the development of the ability to dialogue and express in public the content of the subject to which it is linked.	.566	
14. The use of Augmented Reality (AR) will favour the personal initiative of students	.559	
15. The use of Augmented Reality (AR) will help in solving problems linked to the subject in which it is used	.548	
16. The use of Augmented Reality (AR) will make the teaching methodology used in the classroom promote the development of key competencies	.546	
17. The use of Augmented Reality (AR) will make the teaching methodology used in the classroom more communicative	.542	
18. This translation maintains the formal tone and specificity required for academic discourse at the university level.	.523	
19. The use of Augmented Reality (AR) promotes education in values	.468	
20. The use of Augmented Reality (AR) encourages oral expression linked to the subject in which it is used	.468	
21. The use of Augmented Reality (AR) will promote the creativity of students	.462	
22. The use of Augmented Reality (AR) can enhance the transversal teaching of contents	.458	
23. Augmented Reality (AR) can help prevent bullying	.431	
24. The use of Augmented Reality (AR) will favour student interaction	.396	
25. Learning to use Augmented Reality (AR) by students takes a long time		.668
26. To use Augmented Reality (AR) in the classroom, great technological support is needed		.578
27. The use of Augmented Reality (AR) can be used by subjects with hearing difficulties		-.538
28. To use Augmented Reality (AR) in the classroom it is necessary to have computer and/or programming knowledge.		.531
29. Augmented Reality (AR) is easy for students to use		-.526
30. The use of Augmented Reality (AR) can be used with students who have specific educational needs		-.489
31. The use of Augmented Reality (AR) can be used by subjects with psychological difficulties		-.489
32. Learning to use Augmented Reality (AR) by teachers takes a long time		.473
33. The use of Augmented Reality (AR) can be used by subjects with visual difficulties		.665
34. The use of Augmented Reality (AR) promotes reading comprehension of texts linked to the subject in which it is used		.571
35. The use of Augmented Reality (AR) can be used by subjects with motor difficulties		.566
36. The use of Augmented Reality (AR) can enhance the digital divide		.459

Table 1. Exploratory factorial analysis

Source: Own elaboration

The Cronbach's alpha test yields a value of .89, which, according to the literature (Mateo, 2012), represents a high value, thereby allowing the instrument to be considered reliable

2.3. Sample

The participating population consists of students from the University of Córdoba's master's program in Secondary Education Teacher Training. Their selection was based on a type of incidental sampling for convenience. Among them, we observe that 56.3% are women and 43.7% are men. They have an average age of 27.72 years.

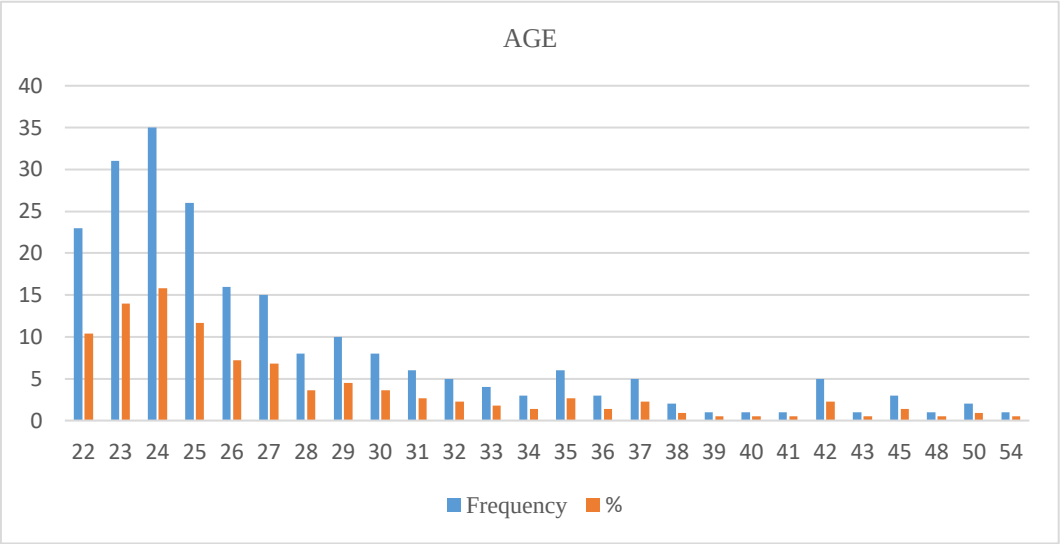

Fig. 1. Sample distribution according to age

Source: Own elaboration

The distribution of the sample based on its macro area of study, as shown in Figure 2, exhibits greater representation from the faculty of Arts and Humanities and lesser from the field of Architecture

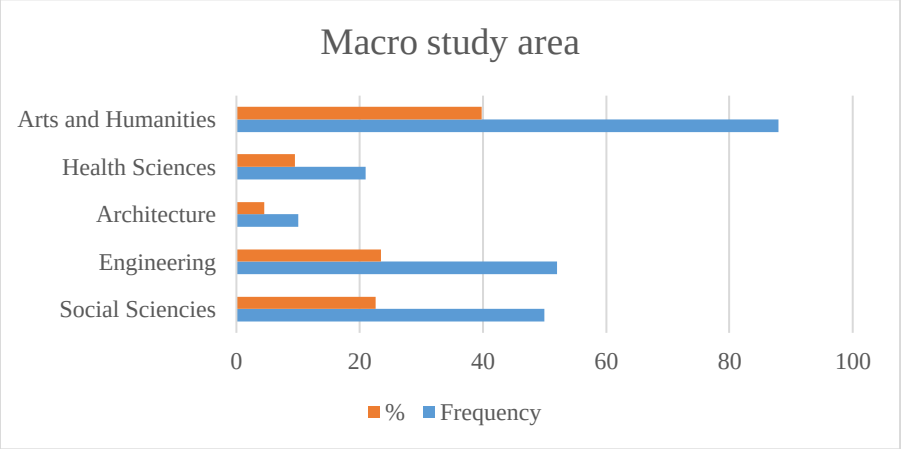

Fig. 2. Sample distribution according to macro study area

Source: Own elaboration

3. RESULTS

After the descriptive study conducted, it has been verified that secondary education teachers in training believe that it is not necessary to spend a lot of time learning how to use Augmented Reality (AR) (M = 2.50; SD = 1.015). On the other hand, they agree that the methodology employed in the classroom will be more active, fostering collaborative (M = 4.26; SD = .758) and cooperative work (M = 4.29; SD =.760) among students as well as group work (M = 4.22; SD = .789).

	M.	SD	Skewness	Standard Error of Skewness	Kurtosis	Standard Error of Kurtosis
1	4.20	.697	-1.263	.163	3.993	.325
2	4.11	.693	-.729	.163	1.165	.325
3	4.29	.712	-1.025	.163	1.932	.325
4	3.57	.868	-.294	.163	.012	.325
5	3.89	.822	-.733	.163	.569	.325
6	3.93	.861	-.769	.163	.196	.325
7	4.43	.660	-1.017	.163	1.103	.325
8	4.14	.781	-.768	.163	.713	.325
9	4.00	.793	-.541	.163	-.010	.325
10	3.77	.736	-.217	.163	-.160	.325
11	3.93	.721	-.696	.163	1.710	.325
12	4.19	.695	-.934	.163	2.224	.325
13	3.46	.910	-.496	.163	-.233	.325
14	3.26	.893	-.260	.163	-.545	.325
15	3.38	.908	-.310	.163	-.347	.325
16	3.62	.883	-.335	.163	-.200	.325
17	4.33	.816	-1.489	.163	2.689	.325
18	4.29	.760	-1.163	.163	1.894	.325
19	4.26	.758	-1.044	.163	1.544	.325
20	4.22	.789	-1.018	.163	1.271	.325
21	3.04	1.284	-.012	.163	-1.213	.325
22	3.91	.848	-.985	.163	1.114	.325
23	3.97	.792	-.825	.163	1.001	.325
24	4.62	.557	-1.428	.163	2.844	.325
25	4.36	.612	-.865	.163	2.854	.325
26	4.44	.581	-.589	.163	.210	.325
27	4.29	.686	-.621	.163	-.031	.325
28	4.24	.669	-.509	.163	.039	.325
29	3.69	1.137	-.886	.163	.632	.325
30	3.17	1.206	-.146	.163	-1.148	.325
31	3.29	1.173	-.095	.163	-1.212	.325
32	3.82	.842	-.886	.163	.632	.325
33	3.16	1.084	.048	.163	-1.133	.325

34	2.50	1.015	1.015	.163	-.251	.325
35	4.25	.599	. -.665	.163	2.943	.325
36	3.24	.852	-.709	.163	-.234	.325

Table 2. Descriptive analysis

Source: Own elaboration

To corroborate whether Hypothesis 1 (H1: Women are more favourable towards using AR for curricular development in secondary education) was met, an independent samples t-test was conducted, which indicated, as shown in Table 3, the existence of very few differences in favour of women.

	F	**Sig.**	**t**	**M.**	**SD.**
The use of Augmented Reality (AR) will make the teaching methodology used in the classroom more active	5.421	.021	-2.383	4.31	.755
			-2.298	**4.52**	.562
The use of Augmented Reality (AR) will make the teaching methodology used in the classroom achieve, more effectively, the objectives of the subject in which it is used.	7.063	.008	-1.526	3.68	.798
			-1.496	**3.83**	.681
The use of Augmented Reality (AR) will help in solving problems linked to the subject in which it is used	9.351	.003	-1.318	3.86	.816
			-1.277	**3.98**	.635
The use of Augmented Reality (AR) will help in carrying out complex tasks associated with real situations or as contextualized as possible, linked to the subject in which it is used	5.131	.024	-1.918	4.09	.678
			-1.926	**4.27**	.700
The use of Augmented Reality (AR) promotes education in values	5.275	.023	-2.688	3.44	.935
			-2.643	**3.76**	.817
Learning to use Augmented Reality (AR) by teachers takes a long time	1.159	.283	-1.287	3.05	1.149
			-1.269	**3.24**	1.027
Learning to use Augmented Reality (AR) by students takes a long time	4.761	.030	-.067	2.49	1.119
			-.065	**2.50**	.930

Table 3. Descriptive analysis

Source: Own elaboration

To determine if Hypothesis 2 (H2: Younger pre-service teachers have a more positive view of incorporating AR as a methodological element in secondary school classrooms) held true, an ANOVA test was conducted after recategorizing the age variable. The results obtained indicate that there are no statistically significant differences, and thus, this hypothesis should be rejected

Upon conducting the ANOVA test using the macro area of study as the selection variable, it has been determined that there are no statistically significant differences, therefore, the proposed hypothesis (H3: Significant differences exist based on the macro-area of study origin.) must be rejected.

4. DISCUSSION

Wang et al. (2018) and Marín et al. (2023) suggests, in line with the findings of this study, that educators require time to effectively implement Augmented Reality (AR) in their classrooms and must therefore receive training that equips them for this integration. Consequently, educational policies should provide specific training for the use of AR in classrooms, especially since the development of teachers' digital competencies is being promoted across various sectors. It is essential that such competencies align with the digital resources to which students have access in their personal live. In conclusion, in terms of training for the use of AR in the classroom, pre-service teachers indicate that what is needed is not a general training but a specific one (Palomo, 2020), which, according to their beliefs, will facilitate the promotion of communication and interdisciplinarity in its use.

The other hand, it has been verified that neither age nor the macro-area of study (that is, the field in which one's university education has been undertaken) are factors that tip the scales in favour of or against the use of Augmented Reality (AR) in the classroom.

Addressing the first objective (To describe the perspective of pre-service secondary education teachers regarding the potential use of Augmented Reality [AR] in secondary school classrooms), we observe that pre-service secondary education teachers believe AR promotes communication and interaction among students, their education in values, and also aids in improving oral expression. Furthermore, they point out that not only is training for its use necessary, but having the physical digital resources to implement it in the classrooms is fundamental (Kljun et al, 2020). Regarding special educational needs, they indicate that it is highly valuable for students with motor difficulties and various degrees of hearing loss (Kamińska et al., 2023) (Objective 2).

5. CONCLUSIONS

In conclusion, we can finalize by stating that: educators require specific training in methodology that involves the use of AR in the classroom**,** and they also need to have access to such resources which should be easily accessible to students. It is also concluded that elements such as gender or age do not determine their use. Lastly, its inclusion in the realm of inclusive education has been proven to be possible and can aid students.

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REFERENCES

1. Acosta, R., Martín, A.V., & Hernández, A. 2019, "Uso de las metodologías de aprendizaje colaborativo con TIC: un análisis desde las creencias del profesorado", *Digital Education Review*, vol. 35. viewed 16 May 2024 <https://doi.org/10.1344/der.2019.35.309-323>
2. Colas, P., de Pablos, J., & Ballesta, J 2018, "Incidencia de las TIC en la enseñanza en el sistema educativo español: una revisión de la investigación", *RED. Revista de Educación a Distancia, vol. 56*, Artic. 2. viewed 16 May 2024. < http://dx.doi.org/10.6018/red/56/2>
3. de la Horra, I. 2017, "Realidad aumentada, una revolución educativa", *EDMETIC*, vol. 6, nº1, pp. 9–22. viewed 13 May 2024. <https://doi.org/10.21071/edmetic.v6i1.5762>
4. Encarnación, L., & Ayala, S. 2021, "Estrategias didácticas a través de la realidad mixta para el aprendizaje teórico-práctico en estudiantes de educación media superior", *RIDE, Revista Iberoamericana de Investigación y Desarrollo Educativo*, vol.11, nº22. viewed 16 May 2024. <https://doi.org/10.23913/ride.v11i22.922>

5. Kamińska D, Zwoliński G, Laska-Leśniewicz A, Raposo R, Vairinhos M, Pereira E, Urem F, Ljubić Hinić M, Haamer RE, & Anbarjafari G. 2023, "Augmented Reality: Current and New Trends in Education", *Electronics*, vol. 12, nº15, pp. 3531. viewed 16 May 2024. <https://doi.org/10.3390/electronics12163531>
6. Kljun, M., Geroimenko, V., & Čopič Pucihar, K. 2020, Augmented Reality in Education: Current Status and Advancement of the Field. In Geroimenko, V. (eds), *Augmented Reality in Education. Springer Series on Cultural Computing*, Springer, Cham. viewed 16 May 2024 <https://doi.org/10.1007/978-3-030-42156-4_1>
7. Marín, V., Sampedro, B.E., & Vega, E. 2023, "Creencias del profesorado de secundaria en torno al uso de la Realidad Mixta", *Revista Electrónica Interuniversitaria de Formación del Profesorado* ,vol.26, nº1, pp. 85-97. viewed 16 May 2024. <https://doi.org/10.6018/reifop.543331>
8. Marín-Díaz, V., Sampedro, B. & Figueroa, J. 2022, "Augmented Reality in the Secondary Education classroom: Teachers' Visions", *Contemporary Educational Technology*, vol. 14, nº2, ep348. viewed 16 May 2024. <https://doi.org/10.30935/cedtech/11523>
9. Martín-Gutiérrez, J., & Contero, M. 2023, "Realidad mixta en educación secundaria: Estado de la cuestión y perspectivas de futuro", *Educación XX1*, vol.26, nº1, pp. 123-145. viewed 16 May 2024.
10. Mateo, J. 2012, La investigación ex post-facto, In R. Bisquerra (coord.), *Metodología de investigación educativa*, pp.195-229, Madrid, La Muralla.
11. Rodríguez, B. 2021, "Realidad Aumentada en Educación Primaria: Revisión sistemática", *Edutec. Revista Electrónica de Tecnología Educativa*, vol. 77, pp. 169-185. viewed 16 May 2024. <https://doi.org/10.21556/edutec.2021.77.1703>
12. Villalustre, L. 2020, "Propuesta metodológica para la integración didáctica de la realidad aumentada en Educación Infantil", *EDMETIC*, vol.9, nº 1, pp. 170–187. viewed 16 May 2024. <https://doi.org/10.21071/edmetic.v9i1.11569>
13. Wang, M., Callaghan, V., Bernhardt, J. *et al.*2018, "Augmented reality in education and training: pedagogical approaches and illustrative case studies", *Journal of Ambient Intelligence and Humanized Computing*, vol.9, pp.1391–1402. viewed 16 May 2024. <https://doi.org/10.1007/s12652-017-0547-8>